



# PML<sup>2</sup>

Analyser

## User Guide



[www.mpfiltri.co.uk](http://www.mpfiltri.co.uk)

200.052-EN

## **COVERS MODEL NUMBERS**

All PML<sup>2</sup> Models

## **SAFETY WARNING**

Hydraulic systems contain dangerous fluids at high pressures and temperatures. Installation, servicing and adjustment is only to be performed by qualified personnel.

Do not tamper with this device.

## **INTERNAL CLEANING**

DO NOT clean the PML<sup>2</sup> or Bottle Sampler with Acetone or similar solvents that are not compatible with the seals. The recommended cleaning fluid for internal flushing is listed in the Fault Finding section, page 60.

The use of a 500µm coarse screen filter, screwed onto the HP connector, is recommended for heavily contaminated systems. Refer to page 59 for details.

# Contents

<b>1</b>	<b>Introduction</b>	<b>5</b>
<b>2</b>	<b>Scope of Supply</b>	<b>7</b>
<b>3</b>	<b>Connecting the PML<sup>2</sup></b>	<b>8</b>
	<i>•Methods of Operation</i>	
<b>4</b>	<b>PC Operation</b>	<b>10</b>
	<i>•Using the Computer Serial Port   •Determining the COM Port   •USB Port   •Operation</i>	
	<i>•Log   •Settings</i>	
<b>5</b>	<b>Normal Test</b>	<b>17</b>
	<i>•Without Moisture Sensor   •With Moisture Sensor</i>	
<b>6</b>	<b>Continuous Sampling</b>	<b>19</b>
	<i>•Continuous Test Basic Operation   •With Moisture Sensor</i>	
<b>7</b>	<b>Moisture Sensor</b>	<b>25</b>
<b>8</b>	<b>Alarms</b>	<b>26</b>
<b>9</b>	<b>External Circuit Relays</b>	<b>28</b>
<b>10</b>	<b>Remote Display - Optional Equipment</b>	<b>30</b>
	<i>•Using the Pushbuttons   •Downloading the Results</i>	
<b>11</b>	<b>Bottle Sampling</b>	<b>34</b>
<b>12</b>	<b>Drain Reservoir and System Pressures</b>	<b>35</b>
<b>13</b>	<b>Flush Valve Opening Times</b>	<b>36</b>

<b>14</b>	<b>Warranty</b>	<b>37</b>
	• <i>Recalibration</i>	
<b>A</b>	<b>Measuring Water in Hydraulic and Lubricating Fluids</b>	<b>39</b>
<b>B</b>	<b>ISO4406:1999 Cleanliness Code System</b>	<b>41</b>
<b>C</b>	<b>NAS1638 Cleanliness Code System</b>	<b>43</b>
<b>D</b>	<b>SAE AS4059 REV.E Cleanliness Classification For Hydraulic Fluids</b>	<b>44</b>
<b>E</b>	<b>Recommendations</b>	<b>46</b>
<b>F</b>	<b>Hydraulic System Target Cleanliness Levels</b>	<b>48</b>
<b>G</b>	<b>New ISO Medium Test Dust and its effect on ISO Contamination Control Standards</b>	<b>50</b>
	• <i>Calibration</i> • <i>New Test Dust Benefits</i> • <i>Effect on Industry</i> • <i>Correlation</i> • <i>Other Standards</i>	
<b>H</b>	<b>Clean working practises</b>	<b>55</b>
<b>I</b>	<b>Specification</b>	<b>57</b>
<b>J</b>	<b>Spare Product / Part Numbers</b>	<b>59</b>
<b>K</b>	<b>Fault Finding</b>	<b>60</b>
	• <i>Low Pressure</i>	

# 1 Introduction

The PML<sup>2</sup> Contamination Analyser is designed to measure and quantify the numbers of solid contaminants in Hydraulic, Lubrication and Transmission applications. The PML<sup>2</sup> is designed to be an accurate, instrument suitable for permanently installed applications utilising mineral oil as the operating fluid.

The instrument uses the light extinction principle whereby 2 laser light systems shine through the fluid and land on photodiodes. When a particle passes through the beam it reduces the amount of light received by the diode, and from this change in condition, the size of the particle can be deduced.

The PML<sup>2</sup>-W has the additional feature to allow the measurement of % saturation of water in oil (RH), and temperature (°C).

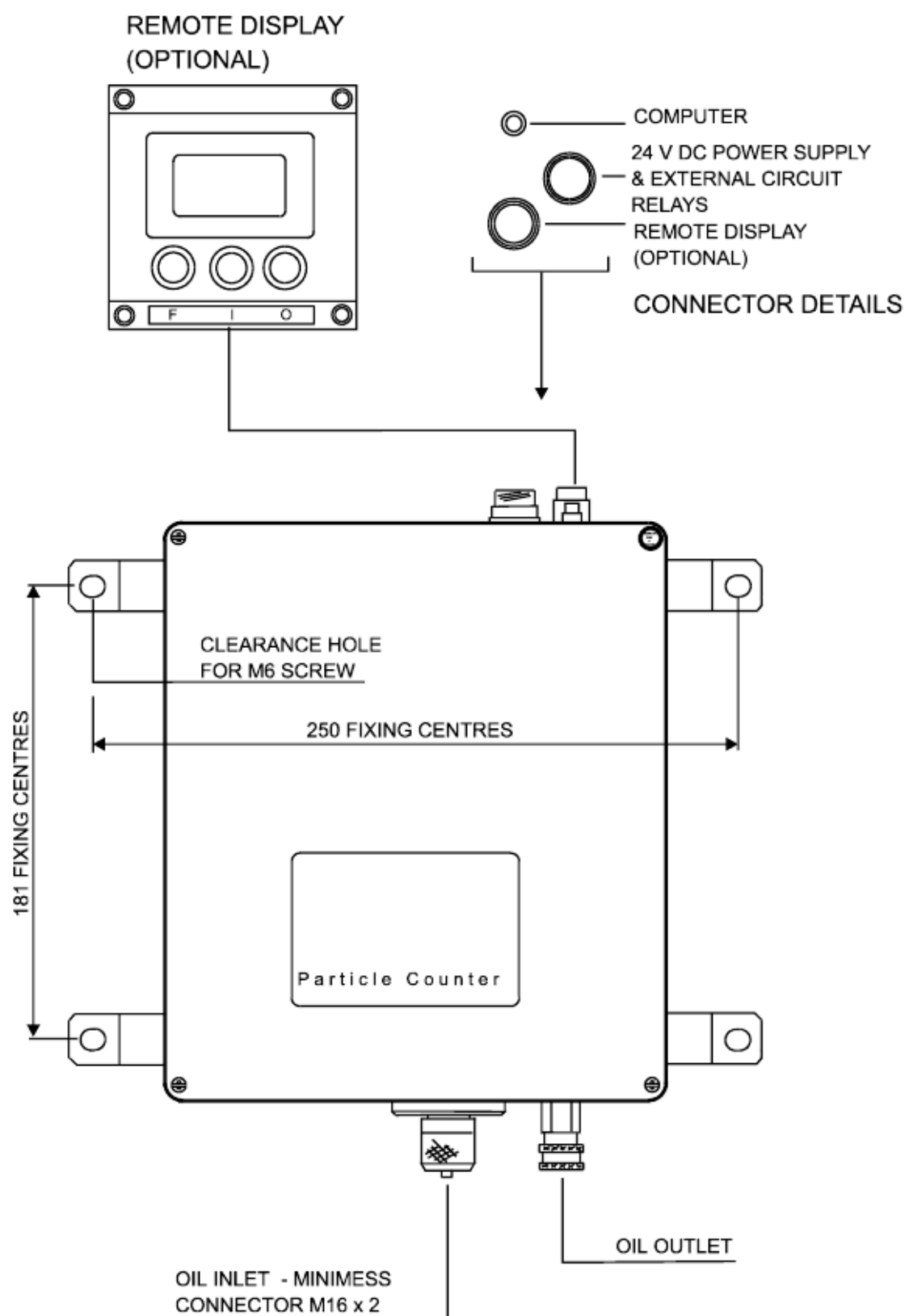
Temperature measurement provides a reference temperature for the Relative Humidity reading (RH).

*Due to the temperature gradient existing between the system tapping point and the RH/temperature module, the temperature reading can be 5°C to 10°C less than the actual system temperature, depending on operating conditions.*

**Hydraulic and Lubricating Systems** consist of sets of continuously moving metal parts, which use hydraulic fluid as the power medium. Hydraulic fluid is also used to create a lubrication film to keep the precision parts separated and it is also used as a cooling medium. The very nature of a hydraulic system is that it produces solid particulate contaminants and these are ever present in all hydraulic systems. There is a revised standard ISO cleanliness code ISO 4406: 1999 which classifies the numbers of particles that can be tolerated within the system and it is these levels of contaminants that the particle counter is designed to measure.<sup>1</sup>

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<sup>1</sup> *ISO Cleanliness Code* – The international standard for reporting solid contaminants is ISO4406: 1999, this standard has been revised to incorporate the change to ISO Medium Test Dust as the calibration standard.



**Figure 1**

## 2 Scope of Supply

Each standard PML<sup>2</sup> supplied consists of the following:-

- 1 x PML<sup>2</sup> particle counter
- 1 x Minimesh hose x 1.5m long
- 1 x Waste hose x 1.5m long ]
- 1 x 24V DC power supply<sup>2</sup>
- 1 x Calibration certificate
- 1 x PML<sup>2</sup> User guide
- 1 x LPA-View CD Rom, software package
- 1 x LPA-View test analysis software manual
- 1 x USB to serial converter (used when computer has only USB ports)
- 1 x PC download cable
- 1 x Multi-core cable x 2.5m long

Optional Equipment:

- Remote display unit, including cable and connector
- 500 µm coarse screen filter ( Part number .SK0040)

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<sup>2</sup> This is a dedicated unit for the PML<sup>2</sup> and should not be used with other MP Filtri UK products, especially the 12V Bottle Sampler Units.

### 3 Connecting the PML<sup>2</sup>

Refer to key drawing on page 6.

1. Fix the PML<sup>2</sup> in place, by bolting through the feet.
  2. Power supply and external circuits: These are two alternative arrangements possible, depending on whether or not the external circuit relays are intended to be used. The alternatives are:
    - a. External circuit relays are not being used - In this case, plug the cable supplied with the power supply into the respective PML<sup>2</sup> connector ( push in gently with the groove at the top, then turn the blue sheath clockwise to lock it in place).
    - b. External circuit relays are intended to be used (see page 28 for further details of external circuits) - In this case:
      - ★ Cut off and discard the connector supplied with the 24 V DC power supply. Identify which is the positive and zero volt cores in the two core cable, using a voltmeter.
      - ★ Connect the 24 V DC positive core to the red core in the multi-core cable supplied with the PML<sup>2</sup>.
      - ★ Connect the 24 V DC zero volt core to the blue core in the multi-core cable.
      - ★ Connect the black, white and yellow cores in accordance with the external circuit details shown on page 28.
      - ★ Connect the outer screen of the multi-core cable to ground.
- The above connections should all be made in a separate junction box, or to a terminal block inside a panel etc.
3. Remote Display (optional equipment) - Plug the cable supplied with the remote display into the respective connector on the PML<sup>2</sup> (The small arrow marked on the connector must be placed at the top when pushing the connector into place. To disconnect, pull the connector outwards).



*Important! Do not connect Waste Fluid Hose to a pressurised system, as this will cause the Analyser to malfunction and could cause internal leakage. The Waste Fluid Hose must be discharged into a waste disposal bottle, or into a tank/vessel vented to atmosphere if running a Continuous test due to the large quantity of oil discharged during a test.*

4. Connect **WASTE FLUID HOSE** to Analyser (waste connector). Push back quick coupling outer ring before connecting / disconnecting hose end.
5. Connect **FLUID SAMPLING HOSE** to Analyser (HP connector)
6. Connect **FLUID SAMPLING HOSE** to the system by means of the minimess connector.

*The system to be monitored must not exceed 400 bar or be less than 2 bar.*

7. Installing **LPA-View Software** – refer to the LPA-View User Manual and follow the CD Installation instructions.
8. Connect **Multi-core cable** into the PC and the other end into the small connector on the PML<sup>2</sup>. If the PC has only USB ports, use the USB to serial converter and follow the instructions on page 12
9. 500 µm Coarse Screen Filter (Optional Equipment) Screw this filter directly onto the PML<sup>2</sup> minimess connector, and then connect the minimess hose to the other end. This filter is recommended for heavily contaminated systems.

## 3.1 Methods of Operation

Users may operate the PML<sup>2</sup> in two ways:-

1. PC Operation
2. Remote Display (optional equipment) see page 30

## 4 PC Operation

PC control of the PML<sup>2</sup> is performed using the Remote Device Dialogue included in the LPA-View software package - refer to the separate LPA-View user manual for details of software installation.

Users may typically wish to operate the Remote Device Dialogue facility in one of two ways:-

- ***Direct Online Operation***

The particle counter is permanently connected to a computer whilst tests are carried out. The operator can set the test parameters, initiate the test, monitor the progress of each test, and download each test as it is completed.

- ***Disconnected Operation using Continuous Test Type***

The PML<sup>2</sup> operates as a stand alone item, performing tests as defined for the Continuous Test. Occasionally the operator connects a PC and uses LPA-View to download the accumulated test data.

### 4.1 Using the Computer Serial Port

This connection is made using the standard computer connecting cable supplied with the PML<sup>2</sup>. (If the computer has only USB to serial ports, use the USB to serial converter and follow the instructions on page 12).

Apply power to the PML<sup>2</sup>, make the PC connection and then start LPA-View running.



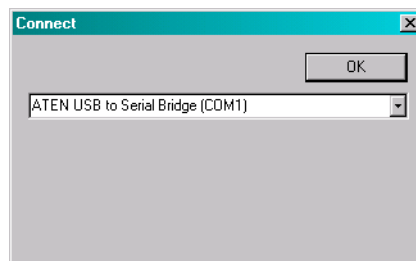
To access the Remote Device facility in LPA-View, press the Remote Control button on the toolbar.

The first time that this is done, the correct communications port (COM port) on the computer has to be selected, as detailed below.

1. The program scans the computer for available ports, and puts them in a list to choose from - this list appears in the box. Click on the right hand side of this box and choose the connection on your computer. Refer to Section below: Determining COM Port.

ID	Machine	Test	Type	Time	Reference	ISO Code	NAS/AS1	AS4059E-2	RH%	Temp. °C
3539	005158	6	0	2008-11-04 13:58:29	CERTIFIED	22/21/17	15	15A/15B/11C/12D/10E/10F	21.68	32.59
3538	005158	5	0	2008-11-04 13:02:28	CERTIFIED	22/21/17	15	15A/15B/12C/12D/11E/10F		
3537	005158	4	0	2008-11-04 12:54:08	CERTIFIED	22/21/17	15	15A/15B/11C/12D/10E/11F		
3536	005158	3	0	2008-11-04 12:48:51	CERTIFIED	22/21/17	15	15A/15B/11C/12D/11E/10F		
3535	005158	2	0	2008-11-04 12:43:39	CERTIFIED	22/21/17	15	15A/15B/11C/12D/11E/10F		
3534	005158	1	3	2008-11-04 12:37:48	CERTIFIED	23/21/17	15	15A/15B/12C/12D/11E/11F		
3533	005158	10	0	2008-11-03 15:04:55	CALIBRATION	22/21/17	15	15A/15B/12C/12D/11E/11F		
3532	005158	4	3	2008-11-03 09:40:32	CALIBRATION	19/18/13	10	9A/9B/7C/9D/6E/0F		
3531	005158	3	2	2008-10-27 14:23:18	CALIBRATION	24/22/20	15	15A/15B/15C/15D/15E/12F	0	0
3530	005158	2	2	2008-10-27 14:22:56	CALIBRATION	24/22/20	15	15A/15B/15C/15D/15E/12F	0	0
3529	005158	1	2	2008-10-27 14:22:44	CALIBRATION	24/22/20	15	15A/15B/15C/15D/15E/12F	0	0
3559	005099	6	0	2008-02-26 16:58:26	CERTIFIED	23/21/17	15	15A/15B/12C/12D/10E/9F	20.57	35.98
3558	005099	5	0	2008-02-26 16:48:21	CERTIFIED	23/21/17	15	15A/15B/12C/12D/10E/10F		
3557	005099	4	0	2008-02-26 16:39:44	CERTIFIED	23/21/17	15	15A/15B/12C/12D/11E/8F		
3556	005099	3	0	2008-02-26 16:33:57	CERTIFIED	23/21/17	15	15A/15B/12C/12D/10E/9F		
3555	005099	2	0	2008-02-26 16:27:58	CERTIFIED	23/21/17	15	15A/15B/12C/12D/11E/10F		
3554	005099	1	3	2008-02-26 16:22:03	CERTIFIED	23/21/17	15	15A/15B/12C/12D/11E/9F		
3553	005099	11	0	2008-02-26 14:07:05	CALIBRATION	22/21/17	15	15A/15B/11C/12D/11E/10F		
3552	005099	10	0	2008-02-26 13:57:43	CALIBRATION	23/21/17	15	15A/15B/11C/12D/10E/9F		
3551	005099	9	0	2008-02-26 11:30:09	CALIBRATION	22/21/17	15	15A/15B/11C/12D/11E/10F		
3550	005099	8	0	2008-02-26 11:23:23	CALIBRATION	22/21/17	15	15A/15B/11C/12D/10E/9F		
3549	005099	7	0	2008-02-26 11:17:42	CALIBRATION	22/21/17	15	15A/15B/11C/12D/11E/10F		
3548	005021	5	0	2007-07-20 12:25:35	CERTIFIED	22/20/16	12	12A/12B/11C/11D/10E/10F	0	30.59
3547	005021	4	0	2007-07-20 12:15:46	CERTIFIED	21/20/16	12	12A/12B/11C/11D/10E/10F		
3546	005021	3	0	2007-07-20 12:09:57	CERTIFIED	21/20/16	12	12A/12B/11C/11D/10E/10F		
3545	005021	2	0	2007-07-20 12:04:06	CERTIFIED	21/20/16	12	12A/12B/10C/11D/10E/10F		
3544	005021	1	3	2007-07-20 11:57:11	CERTIFIED	21/20/16	12	12A/12B/11C/11D/10E/9F		
3543	005021	9	0	2007-07-17 16:47:29	CALIBRATION	22/21/17	15	15A/15B/11C/12D/11E/10F		
3542	005021	8	0	2007-07-17 16:41:37	CALIBRATION	22/21/17	15	15A/15B/11C/12D/10E/10F		
3541	005021	7	0	2007-07-17 16:35:50	CALIBRATION	22/21/17	15	15A/15B/11C/12D/11E/10F		
3540	005021	1	3	2007-07-17 09:17:50	CALIBRATION	16/14/12	8	6A/6B/7C/8D/6E/0F		

**Figure 1** LPA-View



**Figure 2** COM Port selection

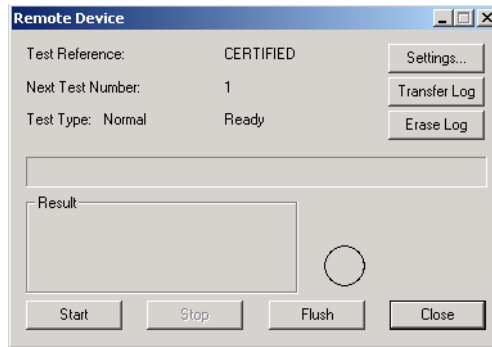
2. Press the OK button, and when the correct port is chosen, the Remote Device dialogue will show the remote device values.

The LPA-View program will remember this selection the next time it is used.

## 4.2 Determining the COM Port

To check the COM port number allocated by the computer for the Serial lead or the USB to Serial Connector:

- *Windows 2000, Windows XP, Windows Vista*



**Figure 3** Remote Device dialogue

- Right click on My Computer icon and then left click on Properties.
- Click on the Hardware tab and then click on the Device Manager Button.
- Click on the plus sign next to Ports (COM & LPT).
- *Windows 7*
  - View the installed devices using Start Button/Devices and Printers.
- You should see an icon representing the port.
  - "Communications port" - if using the Serial lead.
  - "Aten USB to Serial Cable" or "Prolific USB-to-Serial Comm Port" if using an adaptor cable.
- Either of these will have a COM number after it. This is the number you should use when selecting the Com Port.

## 4.3 USB Port

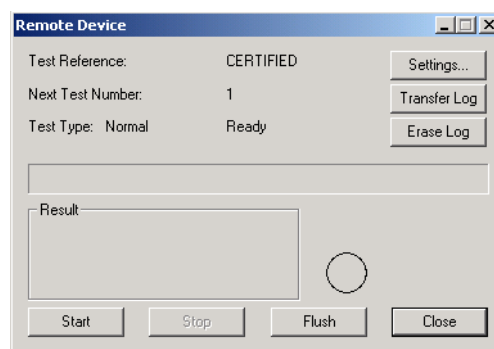
When a built-in computer serial port is not available the USB to serial converter can be used.

- Connect PML<sup>2</sup> to the computer using the Serial lead and the USB to Serial Converter.
- Install the Prolific driver from the file: PL2303\_Prolific\_DriverInstaller\_v110.exe on the provided CD.
- You will need to accept any warnings about making changes to your computer.

- Follow the installer Wizard, accepting the defaults.
- When the Installer has completed, plug in the USB to Serial Adaptor.
- A message should pop up indicating successful hardware installation. Note any COM port number indicated in the message.
- Connect the PML<sup>2</sup> to the computer using the Serial lead and the USB to Serial Converter.
- If necessary, determine the COM port allocated by the computer for this device using the procedure above.

## 4.4 Operation

The following describes the function of the buttons on the Remote Device dialogue.



**Figure 4** Remote Device dialogue

- Start*** Starts sampling and emptying cycle.
- Stop*** Stops test at any point in the sampling / emptying cycle. Next test will start with an emptying cycle before the test commences.
- Flush*** The Flush Valve must be opened to allow fluid to pass through the PML<sup>2</sup>, so that any fluid from the previous test is flushed out of the connecting pipe to eliminate the possibility of cross-contamination between tests. The time for which the flush valve is left open depends on the distance of the PML<sup>2</sup> from the system being sampled and the conditions existing in the drain reservoir - refer to page 36 for guidance. However, for version PML<sup>2</sup>-W

(moisture and temperature indication), every test is automatically preceded by a 3 minute flush period, to allow the moisture sensor to stabilise and give an accurate reading. Therefore, a separate flush period is unnecessary, unless a Continuous Test flush period greater than 3 minutes is required. For the PML<sup>2</sup>-W version the moisture and temperature function can be switched off - refer to Measure Water Content on page 25 for details. Press the Flush button to open the flush valve, and press the Stop button to close it. The Flush indicator turns a yellow colour when flushing is in progress.

***Connect*** Refer to Remote Control section page 10

***Close*** This closes the Remote Device Dialogue box.

## 4.5 Log

The PML<sup>2</sup> can be operated permanently connected to a computer with the Remote Device dialogue open. This allows the user to set up a continuously updated trend graph and list view. As each test is completed, the trend graph and list view are updated.

However, it is not necessary to keep the Remote Device dialogue open and computer connected after the test has been initiated, although most users will find this more convenient. This fact is especially useful for the continuous test mode, when a test sequence might be programmed to take several hours. In this case, pressing the Transfer Log button (describe below) will transfer the complete result log of the PML<sup>2</sup> into the test database.

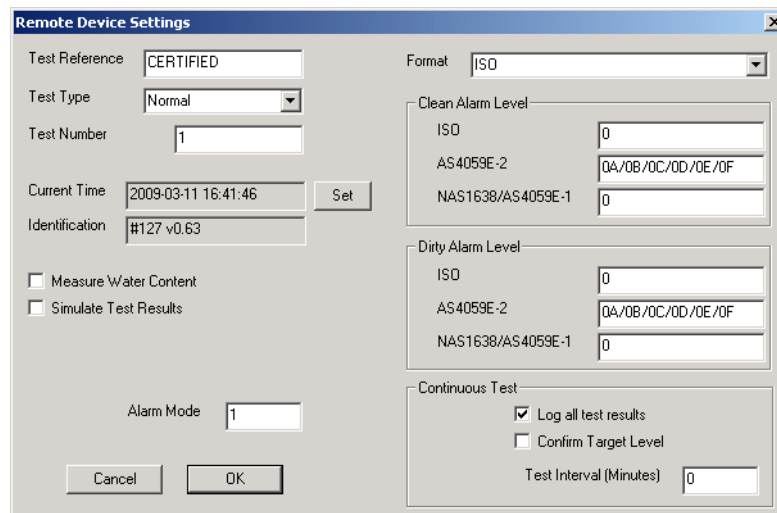
***Transfer Log*** As explained immediately above, if the PML<sup>2</sup> has been operated as a stand alone item, then connecting the computer to the PML<sup>2</sup> and pressing the Transfer button will transfer all the test results into the test database.

The PML<sup>2</sup> has a memory capacity of approximately 600 tests. When this memory is full, the earliest of the test records will be over-written by the new tests.

**Erase Log** This erases all the test results that are stored in the PML<sup>2</sup> memory.

**Settings** Opens the Settings dialogue, described in the next section.

## 4.6 Settings

The image shows a 'Remote Device Settings' dialogue box. It contains several input fields and checkboxes. On the left, there are fields for 'Test Reference' (containing 'CERTIFIED'), 'Test Type' (a dropdown menu showing 'Normal'), 'Test Number' (containing '1'), 'Current Time' (containing '2009-03-11 16:41:46' with a 'Set' button), and 'Identification' (containing '#127 v0.63'). Below these are two checkboxes: 'Measure Water Content' and 'Simulate Test Results', both of which are unchecked. At the bottom left is an 'Alarm Mode' field containing '1', and 'Cancel' and 'OK' buttons. On the right, there is a 'Format' dropdown menu showing 'ISO'. Below this are two sections: 'Clean Alarm Level' and 'Dirty Alarm Level'. Each section has three rows of input fields for 'ISO', 'AS4059E-2', and 'NAS1638/AS4059E-1', all containing '0'. At the bottom right is a 'Continuous Test' section with two checkboxes: 'Log all test results' (checked) and 'Confirm Target Level' (unchecked), and a 'Test Interval (Minutes)' field containing '0'.

**Figure 5** Remote Device Settings dialogue

Use this dialogue box to examine the current settings stored in the PML<sup>2</sup>, and change the settings.

After making any changes, pressing the OK button will update the PML<sup>2</sup> with the new settings. Or press Cancel to leave the settings as they were.

**Test Reference** Type in this box the description you wish to use for the test, e.g. Vehicle 012. Up to 14 characters may be used.

**Test Type** Used to select one of the five available test types. It is recommended that the PML<sup>2</sup> be usually operated in either the Normal test mode or the Continuous test mode, until the user is fully familiar with the features. The PML<sup>2</sup> test menu is harmonised with that of MP Filtri UK's other particle analysers and so can also perform Short, Triple and Dynamic tests.

**Normal** Single Test: 15ml sample volume.

**Dynamic** A comprehensive triple test<sup>3</sup> with results average: 30 ml sample volume comprised of three 10ml sampling and emptying cycles. Allows the effect of system fluctuations to be measured over a longer period of time. The system

**Triple / Bottle Sampling** A triple test with results average and quicker than the Dynamic Test: 24ml sample volume comprised of three individual 8 ml samples tested consecutively. For Bottle Sampling refer to separate User Guide.

**Continuous** For detailed instructions refer to Continuous Sampling, page 19.

**Short** Single Test: 8 ml sample volume. This provides results in less time than the Normal Test. It is not recommended for oil samples cleaner than ISO 17/15/12 (NAS 6), as the accuracy of the result might be compromised by the 'small' sample volume

**Test Number** Input desired number, e.g. '123'. (Test number will automatically increment for each successive test).

**Simulate Test Results** This is useful for checking device communications and familiarisation with the software, especially when an oil supply is not available. When a simulated test is performed, the particle counter will generate test results without being connected to a hydraulic system.

**Format** Choose the preferred display format (ISO, Nas1638 / AS4059E-1, AS4059E-2). This also sets which of the cleanliness targets is used for the continuous test mode.

**Serial Number** The serial number of the PML<sup>2</sup>. This is recorded in each test result. (The serial number, together with the test timestamp, uniquely identify the test record. These two parameters are used to avoid duplication of test records.)

**Software Revision** This identifies the program running on the PML<sup>2</sup>.

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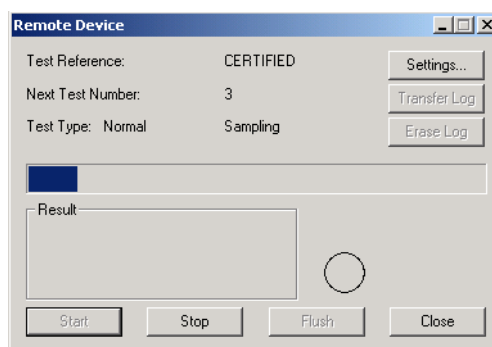
<sup>3</sup> Results will be displayed upon completion of three tests – including emptying cycle



# 5 Normal Test

## 5.1 Without Moisture Sensor

1. Input settings as described on page 15 for the following:-
  - Test Reference
  - Test Type - select Normal
  - Test Number
  - Format
2. Press OK button to return to Remote Device dialogue.
3. Press Flush button to open flush valve - flush indicator turns yellow colour to indicate valve is open. Leave valve open until at least 200ml has passed to waste. Refer to page 36 for more information about flushing times.
4. Press Stop button to close flush valve.
5. Press Start button. The PML<sup>2</sup> will now commence the sampling cycle.
6. The completion bar indicates progress of the test and the status is shown as Sampling.



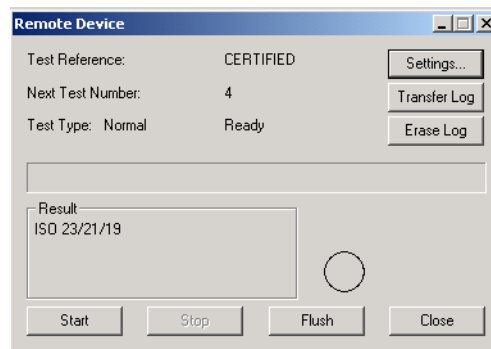
**Figure 1** A Test in Progress

- At the end of the Sampling cycle the test result will be displayed in the Remote Device dialogue box.

If the Remote Device dialogue is open, the test results will be automatically transferred to the test database.

Following the sampling results the PML<sup>2</sup> discharges the sample fluid to waste. Test status is shown as Emptying.

When emptying cycle is finished the status is shown as Ready, and another test can then be started.



**Figure 2** A Completed Test

## 5.2 With Moisture Sensor

For the PML<sup>2</sup>-W the procedure is similar to that detailed for the PML<sup>2</sup> without moisture sensor (previous section), except when the Start button is pressed the flush valve will open automatically for a period of 3 minutes, to allow the moisture sensor to stabilise and give an accurated reading. ("Measure Water Content" box in the Remote Device Setting dialogue has to be ticked to obtain a result).

Temperature is displayed in °C and moisture is expressed in % RH (Relative Humidity).

## 6 Continuous Sampling

The Analyser can be selected for continuous testing at set time intervals.

Once continuous sampling has started the PML<sup>2</sup>'s flush valve automatically opens and closes before each test. This allows representative fluid to reach the sensing arrangement before the 15ml sampling test commences. The flush valve automatically opens at the end of the sampling cycle and remains open whilst the analyser is emptying to waste the sample fluid from the previous test.<sup>4</sup> Additionally, depending on the time set for Minutes Between Tests, the Flush valve operates as follows:-

***Time set to 0*** – At the end of the analyser's emptying cycle the flush valve automatically closes and the next sampling test immediately starts.

***Time set to between 1 and 5*** – After the analyser's emptying cycle has finished the flush valve remains open for the time set, then automatically closes before the next sampling test.

***Time set to between 6 and 30000*** – Flush valve automatically closes after the emptying cycle has finished and remains closed until 5 minutes before the next sample test is programmed to start.

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<sup>4</sup> The servo motor operating the Flush valve exhibits a slight 'ticking' noise, both when it is open and closed. This is normal.

## 6.1 Continuous Test Basic Operation

1. Follow the instructions on page 15 for inputting settings - select Continuous Test Type.
2. Input Test Interval - input the time in minutes that is required between the end of a test and the beginning of a new test.
3. Input:
  - 0 (zero) ISO Cleanliness Target
  - 0 (zero) Nas1638/AS4059E-1 Cleanliness Target
  - 0 (zero) AS4059E-2 Cleanliness target (displayed as: \*A / \*B / \*C / \*D / \*E / \*F after pressing OK)
  - 0 (zero) ISO Dirty Alarm Target
  - 0 (zero) NAS 1638/AS4059E-1 Dirty Alarm Target
  - 0 (zero) AS4059E-2 Dirty Alarm Target (displayed as: \*A / \*B / \*C / \*D / \*E / \*F after pressing OK)
4. Insert a tick in the "Log all test results" box. This will log every test that is carried out in the continuous test mode, into the memory of the PML<sup>2</sup>. If the box is not ticked none of the test results will be stored in the memory of the PML<sup>2</sup>.
5. Press OK button to save settings and return to Remote Device dialogue.
6. Press Flush button to open flush valve - flush indicator turns yellow to indicate valve is open. Leave valve open until at least 200ml has passed to waste. Refer to page 36 for more information flushing times.
7. Press Stop button to close flush valve.
8. Press Start button. The PML<sup>2</sup> will now commence the sampling cycle.
9. The completion progress bar indicates the status of the test. Results will be automatically displayed on the Remote Device dialogue after each test.
10. The status is shown as Waiting between the ending of one test and the starting of the next test.

11. Press the Stop button at any time in the cycle to end the continuous sampling. The test status will show as Idle.

### 6.1.1 Continuous Sampling - with Clean Alarm Levels - Alarm Mode 1

The screenshot shows the 'Remote Device Settings' dialog box. It contains the following fields and options:

- Test Reference:** CERTIFIED
- Test Type:** Continuous (dropdown menu)
- Test Number:** 4
- Current Time:** 2009-03-12 11:16:11 (with a 'Set' button)
- Identification:** #127 v0.63
- ☐ Measure Water Content
- ☐ Simulate Test Results
- Alarm Mode:** 1
- Format:** ISO (dropdown menu)
- Clean Alarm Level:**
  - ISO: 0
  - AS4059E-2: 0A/0B/0C/0D/0E/0F
  - NAS1638/AS4059E-1: 0
- Dirty Alarm Level:**
  - ISO: 0
  - AS4059E-2: 0A/0B/0C/0D/0E/0F
  - NAS1638/AS4059E-1: 0
- Continuous Test:**
  - ☒ Log all test results
  - ☐ Confirm Target Level
  - Test Interval (Minutes):** 20

Buttons: Cancel, OK, Set.

**Figure 1** Continuous Test Settings

This operating mode is similar to the Basic Operation, but in this mode the PML<sup>2</sup> will stop testing when the specified clean alarm level is achieved.

A status of COMPLETED is shown when the specified clean alarm level is achieved. (For other Alarm Modes refer to page 27).

- Follow the instructions on page 15 for inputting settings - select Continuous Test Type.
- Input Test Interval- input the time in minutes that is required between the end of a test and the beginning of a new test.
- Cleanliness Target options:

Clean Alarm Level (ISO) - Input desired Clean Alarm Level in the code format Number/ Number/ Number – any code number combination can be input, from code 5 to 24, example 10/9/5.

For continuous testing until the ISO Code is achieved, select ISO Format in the Remote Device Settings dialogue, as described under the previous section on page 15.

Testing will automatically continue until each of the three numbers in the Code have been achieved (or cleaner).

**Figure 2** Setting ISO Target Cleanliness Level

Clean Alarm Level (NAS1638 / AS4059E-1) - Input desired Clean Alarm Level, as a single Class number in the range 2 to 12 inclusive.

For continuous testing until the (NAS1638 / AS4059E-1) Class is achieved, select NAS Format or AS4059E Table 1, as described on page 15. Testing will automatically continue until the Class number has been achieved at each of the five micron size ranges covered by NAS 1638 & AS4059E Table 1. Note: AS4059E-1 denotes Table 1 of the AS4059E standard.

Clean Alarm Level (AS4059E-2) - Input desired Clean Alarm Level in the format 1A/2B/3C/4D/5E/6F in the following range:

Size Code A: 000 to 12

Size Code B: 00 to 12

Size Code C: 00 to 12

Size Code D: 2 to 12

Size Code E: 4 to 12

Size Code F: 7 to 12

Example, 4A/4B/5C/6D/6E/7F.

For continuous testing until the AS4059E Table 2 size codes are achieved, select AS4059E TABLE 2 FORMAT, as described on page 15. Testing will automatically continue until the Class number has been achieved at each of the six Size Codes.

Also, the PML<sup>2</sup> will handle deviations from the above format intelligently. The size code can be out of order: 7F / 4A / 5C / 4B / 6E / 6D

If any sizes are missing, they will be assigned the “\*” value. The effect of this is a “don’t care” value when used as the cleanliness target. For example, 6B/6C/7D is translated as \*A/6B/6C/7D/\*E/\*F. In this case, testing will continue until the B, C and D Classes are less than or equal to 6, 6, 7 respectively. The A, E and F Classes are effectively ignored since they cannot ever be “worse” than a “\*” Class. Note: AS4059E-2 denotes Table 2 of the AS4059E standard.

- 2Log all test results” box - A tick in this box will log every test that is carried out on the continuous test mode, into the memory of the PML<sup>2</sup>. If the box is not ticked then the PML<sup>2</sup> will only store the results of the test when the Target Cleanliness Level is achieved - this saves on memory space.

The PML<sup>2</sup> has a memory capacity of approximately 600 tests. When this memory is full, the earliest of the test records will be over-written by the newest tests.

- Inserting a tick in the "Confirm Target Level” box instructs the PML<sup>2</sup> to repeat the sampling cycle until the target cleanliness level has been achieved in two consecutive samples, before the Complete status is displayed.

Leaving the "Confirm Target Level” box blank permits the target cleanliness level to be achieved only one time before the Complete status is displayed.

- Press OK button to save settings and return to Remote Device dialogue.
- Press Flush button to open flush valve - flush indicator turns yellow to indicate valve is open. Leave valve open until at least 200ml has passed to waste. Refer to page 36 for more information about flushing times.
- Press Stop button to close flush valve.
- Press Start button, the PML<sup>2</sup> will now commence the sampling cycle.

- The Completion progress bar indicates the status of the test. Results will be automatically displayed on the Remote Device dialogue after each test.
- The status is shown as Waiting between the ending of one test and the starting of the next test.
- Press the Stop button at any time in the cycle to end the continuous sampling. The test status will show as Idle.

## 6.2 With Moisture Sensor

Continuous Test - Basic Operation and  
Continuous Test - with Target Cleanliness Level

The procedure is similar to that detailed for the PML<sup>2</sup> without moisture sensor (previous section), except when the Start button is pressed the flush valve will open automatically for a period of at least 3 minutes before the test commences; this is to allow the moisture sensor to stabilise and give an accurate reading. ("Measure Water Content" box in the Remote Device Setting dialogue has to be ticked to obtain a result).

For example, if zero minutes is input in the "Test Interval" box, the effective time between one test finishing and the next starting will be 3 minutes. Temperature is displayed in °C and moisture is expressed in % RH (Relative Humidity).



## 7 Moisture Sensor

The PML<sup>2</sup> version fitted with the optional moisture sensor module allows both measurement of % saturation of water in oil (Relative Humidity) and temperature. These are displayed as RH % and °C on the main/test progress screen and on the printed results.

Temperature measurement provides a reference temperature for the RH reading.

Due to the temperature gradient existing between the system tapping point and the RH/temperature module, the temperature reading can be 5°C to 10°C less than the actual system temperature, depending on operating conditions.

The PML<sup>2</sup> can be configured to do a test with or without the moisture sensor selected. If the moisture sensor has been selected, the flush valve will open automatically for a period of 3 minutes before the particle count test commences. This is to allow the moisture sensor to stabilise and give an accurate reading.

Remote Device Settings

Test Reference: CERTIFIED

Test Type: Continuous

Test Number: 4

Current Time: 2009-03-12 11:20:24

Identification: #127 v0.63

☒ Measure Water Content

☐ Simulate Test Results

Alarm Mode: 1

Format: ISO

Clean Alarm Level

ISO: 23/21/19

AS4059E-2: 0A/0B/0C/0D/0E/0F

NAS1638/AS4059E-1: 0

Dirty Alarm Level

ISO: 0

AS4059E-2: 0A/0B/0C/0D/0E/0F

NAS1638/AS4059E-1: 0

Continuous Test

☒ Log all test results

☒ Confirm Target Level

Test Interval (Minutes): 20

**Figure 1** Measure Water Content Enabled

To switch the moisture sensor on, select the Settings option in the Remote Device dialogue, as described on page 15. The "Measure Water Content" box should be ticked.

## 8 Alarms

Access the Remote Device dialogue as described on page 15. The Alarm Options will be displayed.

- 1) Alarm Mode: 1
- 2) Dirty Alarm Level (ISO): 0
- 3) Dirty Alarm Level (NAS1638 / AS4059E-1): 0
- 4) Dirty Alarm Level (AS4059E-2):  
1A/2B/3C/4D/5E/6F

The PML<sup>2</sup> includes two solid state relays for connections to an external circuit. These can be arranged to function as follows:

### 1 Alarm Mode: 0

Selecting option 0 switches relays 1 and 2 always off.

### 2 Alarm Mode: 1

Selecting option 1 will configure relays 1 and 2 as described on page 28 - refer to the examples given on the simple wiring diagrams. Clean alarm levels are set in accordance with the instructions starting on page 21. Alarm mode 1 is used in conjunction with the Continuous Sampling test type, enabling the Analyser to operate continuously until the specified clean alarm level is achieved.

### 3 Alarm Mode: 2

Selecting option 2 arranges the relays to operate when the Clean and Dirty alarm levels are reached/exceeded. Alarm mode 2 will normally be used in conjunction with the Continuous test type (refer to page 20), but can be used with all other test types as well.

Set the Clean and Dirty alarm levels by inputting the desired levels in to the Remote Device dialogue on (page 15, also setting the appropriate result format to ISO, NAS or AS4059, as described on page 21).

Both relays are initially off and remain off until an alarm level has been reached/exceeded.

The following illustrates the switching logic of the Relays :-

### **Relay 1 (Dirty)**

NAS/AS4059E-1 single number	result > set limit	On
	result <= set limit	Off
ISO/AS4059E-2 multi-part	any result > corresponding set limit	On
	all results <= corresponding set limit	Off

### **Relay 2 (Clean)**

NAS/AS4059E-1 single number	result <= set limit	On
	result > set limit	Off
ISO/AS4059E-2 multi-part	all results <= corresponding set limit	On
	any result > corresponding set limit	Off

### **Alarm Modes: 3 and 4**

These are reserved for future development.

## 9 External Circuit Relays

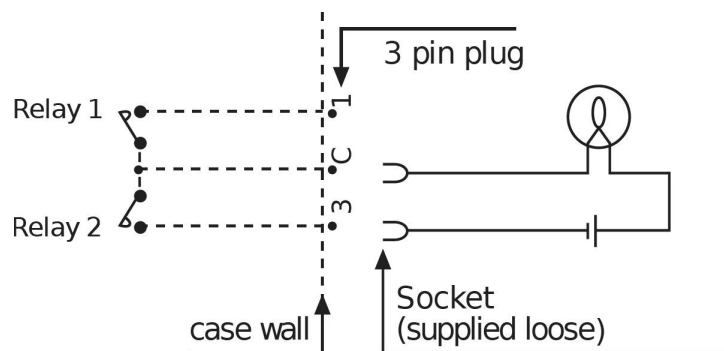
Page 8, item b explains actions to be taken if it is intended to use the external circuit relays that are built into the PML<sup>2</sup>.

There are two solid state relays for external circuit use. The function of these relays is illustrated in the following simple wiring diagram, using a battery and bulb circuit for illustrative purposes.

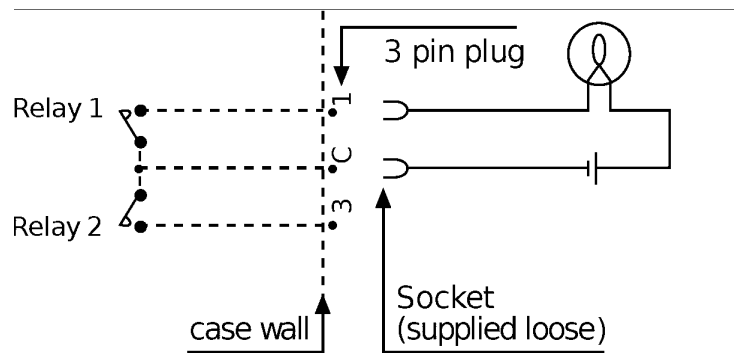
Each relay is designed for a maximum current of 1 amp at 24 volt nominal AC or DC (absolute maximum 60 volt peak). Operation above these limits will cause irreparable damage to the relays.

If the User requires to switch voltages/currents in excess of the above maximum limits, then separate higher rated interposing relays will need to be incorporated into the final electrical scheme designed by the User.

In the multi-core cable that is supplied with the PML<sup>2</sup> there are three cores that are used to connect with the relays. These cores are colour coded black, white and yellow, see diagrams below. *The green core is not used and can be cut-off.*



**Figure 1** Example 1: Bulb illuminates when target cleanliness level is achieved (Completed status) and is off during sampling.

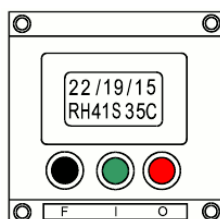


**Figure 2** Example 2: Bulb illuminates during sampling and extinguishes when target cleanliness level is achieved (Completed status). (Relay 1 is also switched during Normal, Dynamic and Triple test types. Relay will open at test end or when stop button is pressed.)

# 10 Remote Display - Optional Equipment

The PML<sup>2</sup> can be operated from the Remote Display unit, with or without being permanently connected to a computer.

Setting the types of test, downloading test results etc. are implemented using a PC running LPA-View software - refer to page 10 for details.



**Figure 1**

The LCD screen displays two lines of eight alpha-numeric characters. The top line is used to display the test code; the bottom line – showing RH % (Relative Humidity) and Temperature °C – only appears on the PML<sup>2</sup>-W version.

When first switched on the display unit will show the letters MP Filtri UK - Remote Display Unit on the first screen shot, followed by a software version number on the second screen shot, e.g. RDU V0.6.

## 1 Status Letters

During a test a Status letter flashes in the centre of the bottom line.

The letters denote the following:-

- System ready or user stop
- S* Sampling
- E* Emptying
- F* Flushing
- L* Low Pressure (refer to page 60)

**W** Waiting (Continuous testing only)

**C** Test Completed (Continuous testing only)

## 2 Pushbuttons

- **F** – Black – Toggles the flush valve open and closed.
- **I** – Green – Starts a test.
- **O** – Red – Aborts a test.

## 3 Cleanliness Codes

**ISO Code** – The test result is displayed as a three part code e.g. 22/19/16.

**NAS1638/AS4059E-1 Class** – A single number is displayed, which is the highest recorded in all of the sizes, e.g. NAS 8.

**AS4059E-2** – A single number is displayed, which is the highest record for all of the sizes, e.g. AS 7.

## 10.1 Using the Pushbuttons

All new PML<sup>2</sup>'s are factory set to perform a Normal test, which consists of one test sampling 15ml of fluid. Other test types can be selected using a PC running LPA-View - refer to page 10.

When running a Normal test the user will first make the oil and power supply connections as described on page 8.

Follow the actions below to perform a Normal test:

- ***Press Flush Pushbutton (F)***

This will open the flush valve to allow fluid to pass through the PML<sup>2</sup>, so that any fluid from the previous test is flushed out of the connecting pipe to eliminate the possibility of cross-contamination between tests. The time for which the flush valve is left open depends on the distance of the PML<sup>2</sup> from the system being sampled. As

a guide, a 200ml flush volume is recommended when using the 1.5m long mininess hose. Refer to page 36 for more information about flushing times.

After the flush volume has been discharged to waste the flush valve may be manually closed by again pressing pushbutton F. Alternatively, the flush valve will close automatically when pushbutton Start (I) is pressed.

Note! For version PML<sup>2</sup>-W (moisture and temperature indication), every test is automatically preceded by a 3 minute flush period, to allow the moisture sensor to stabilise and give an accurate reading. The 3 minute period starts from the time the Start pushbutton (I) is pressed. Therefore, a separate flush period is unnecessary, unless a flush period greater than 3 minutes is required. For the PML<sup>2</sup>-W version the moisture and temperature function can be switched off - refer to page 18 for details.

- ***Press Start Pushbutton***

This will initiate the commencement of a test. Each test comprises a sampling cycle that sizes and counts the particles in a 15ml volume of test fluid, followed by an emptying cycle during which the 15ml of fluid is discharged to waste. At the end of the emptying cycle the PML<sup>2</sup> will come to rest and the test results will be displayed on the LCD screen.

- ***Stop Pushbutton (O)***

This optionally *aborts* the test at any point in the sampling/ emptying cycle. Please note: The next test will start with an emptying cycle before the test commences.

## **10.2 Downloading the Results**

After using Pushbutton Operation the test results can be downloaded.

The PML<sup>2</sup> has a memory capacity of approximately 600 tests. When this memory is full, the earliest of the test records will be over-written by the new tests.

Connect the PML<sup>2</sup> to a PC running LPA-View and follow the instructions given to Transfer Log on page 14.

It is important to set the Test Reference (refer to page 15) before transferring the test results, as all results transferred to the database will be given the same Test Reference that is active at the time in the Settings dialogue box.



If the User is carrying out tests at different locations and wishes to give the tests different references it is necessary to download the tests after each location, followed by changing the Test Reference for the next location. Alternatively, the Test Reference may be edited at a later date by accessing the individual test record using LPA-View - refer to the separate LPA-View test analysis software manual.

# 11 Bottle Sampling

*An alternative to operating on-line is to use MP Filtri UK's Bottle Sampling Unit to test oil contained in bottles. Refer to the separate User Guide for details.*

# 12 Drain Reservoir and System Pressures

The PML<sup>2</sup> is produced in two standard models, as detailed below.

- Model A (Design Reference 30):
  - Minimum oil inlet pressure: 2 bar
  - Maximum oil inlet pressure: 400 bar
  - Drain Reservoir / System: Atmospheric pressure, zero back pressure.
- Model B (Design Reference 31):
  - Minimum oil inlet pressure: 10 bar
  - Maximum oil inlet pressure: 400 bar
  - Drain Reservoir / System: Back pressure not exceeding 1 bar

The PML<sup>2</sup> model suffix letter is stamped on the serial number plate, after the number.

# 13 Flush Valve Opening Times

The table below shows the flush valve opening times that are required to achieve a 200ml flush volume, for different conditions.

Model Type <sup>5</sup>	Oil Inlet Pressure	Drain Pressure	Approximate Time for 200ml Flush Volume <sup>6</sup>
Model A	2 bar	Atmospheric pressure, zero back pressure	2 minutes 30 seconds
Model B	10 bar	Back pressure not exceeding 0.5 bar	1 minute 20 seconds
Model B	10 bar	Back pressure not exceeding 1.0 bar	2 minutes

The above flush times assume that the oil inlet hose from the sampling point to the PML<sup>2</sup> does not exceed 1.5m in length. Longer lengths of hose should be avoided, as they can become a source of cross-contamination between tests. However, if a hose length greater than 1.5m is used, the flushing time should be increased pro-rata.

---

<sup>5</sup> refer to previous section

<sup>6</sup> ISO 32 oil grade at 35°C

# 14 Warranty

The PML<sup>2</sup> is guaranteed for 12 months upon receipt of the Analyser, subject to it being used for the purpose intended and operated in accordance with this User Guide.

## 14.1 Recalibration

MP Filtri UK will only verify the accuracy of the PML<sup>2</sup> if the unit is recalibrated every 12 months.

Please ensure that the test results in the Log are downloaded to LPA-View before the PML<sup>2</sup> is despatched, in case action taken by MP Filtri UK during the service / recalibration causes the Log to be cleared.

It is requested that only the PML<sup>2</sup>, not the support case or any other ancillaries, be returned for recalibration.

MP Filtri UK will not be held responsible for any items returned as such.

Ensure that the PML<sup>2</sup> is packed appropriately for transportation.



# Measuring Water in Hydraulic and Lubricating Fluids

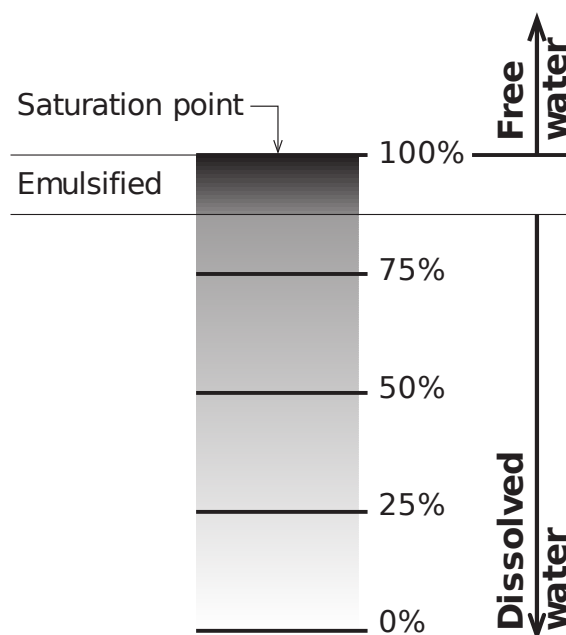
*From North Notts Fluid Power Centre*

In mineral oils and non aqueous fire resistant fluids water is undesirable. Mineral oil usually has a water content of 50-300 ppm which it can support without adverse consequences.

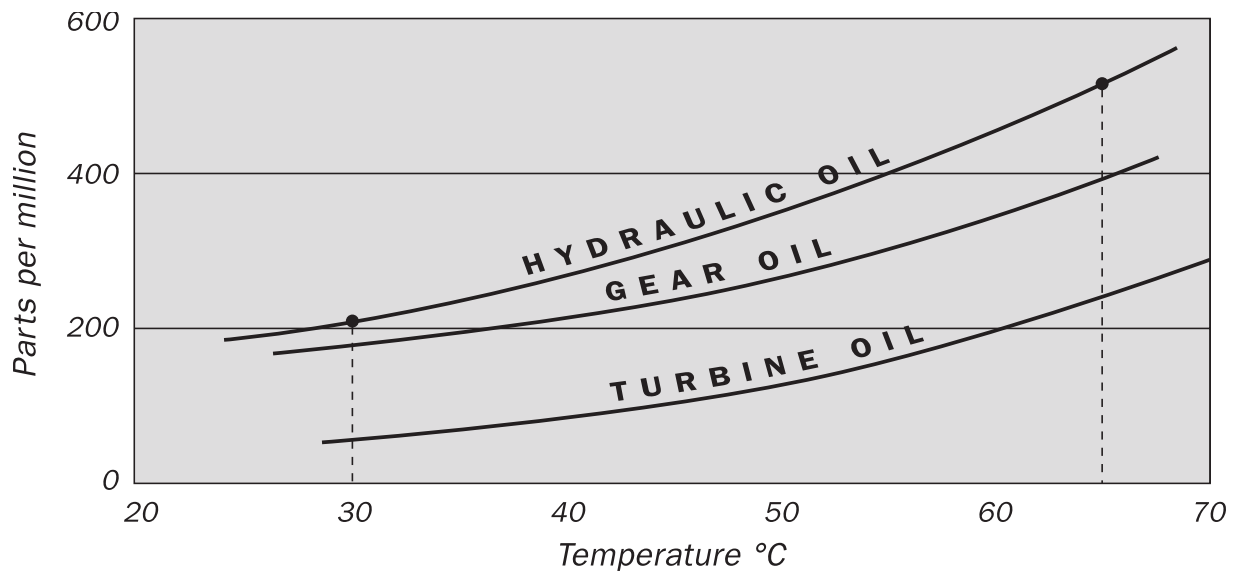
Once the water content exceeds about 500ppm the oil starts to appear hazy. Above this level there is a danger of free water accumulating in the system in areas of low flow. This can lead to corrosion and accelerated wear. Similarly, fire resistant fluids have a natural water content which may be different to mineral oils.

## Saturation Levels

Since the effects of free (also emulsified) water is more harmful than those of dissolved water, water levels should remain well below the saturation point. However, even water in solution can cause damage and therefore every reasonable effort should be made to keep saturation levels as low as possible. There is no such thing as too little water. As a guideline, we recommend maintaining saturation levels below 50% in all equipment.



## Typical Water Saturation Levels For New Oils



**Figure I**

Examples: Hydraulic oil @ 30°C = 200ppm = 100% saturation  
Hydraulic oil @ 65°C = 500ppm = 100% saturation



## ISO4406:1999 Cleanliness Code System

The International Standards Organization standard ISO 4406:1999 is the preferred method of quoting the number of solid contaminant particles in a sample.

The code is constructed from the combination of three scale numbers selected from the following table.

The *first* scale number represents the number of particles in a millilitre sample of the fluid that are larger than 4  $\mu\text{m(c)}$ .

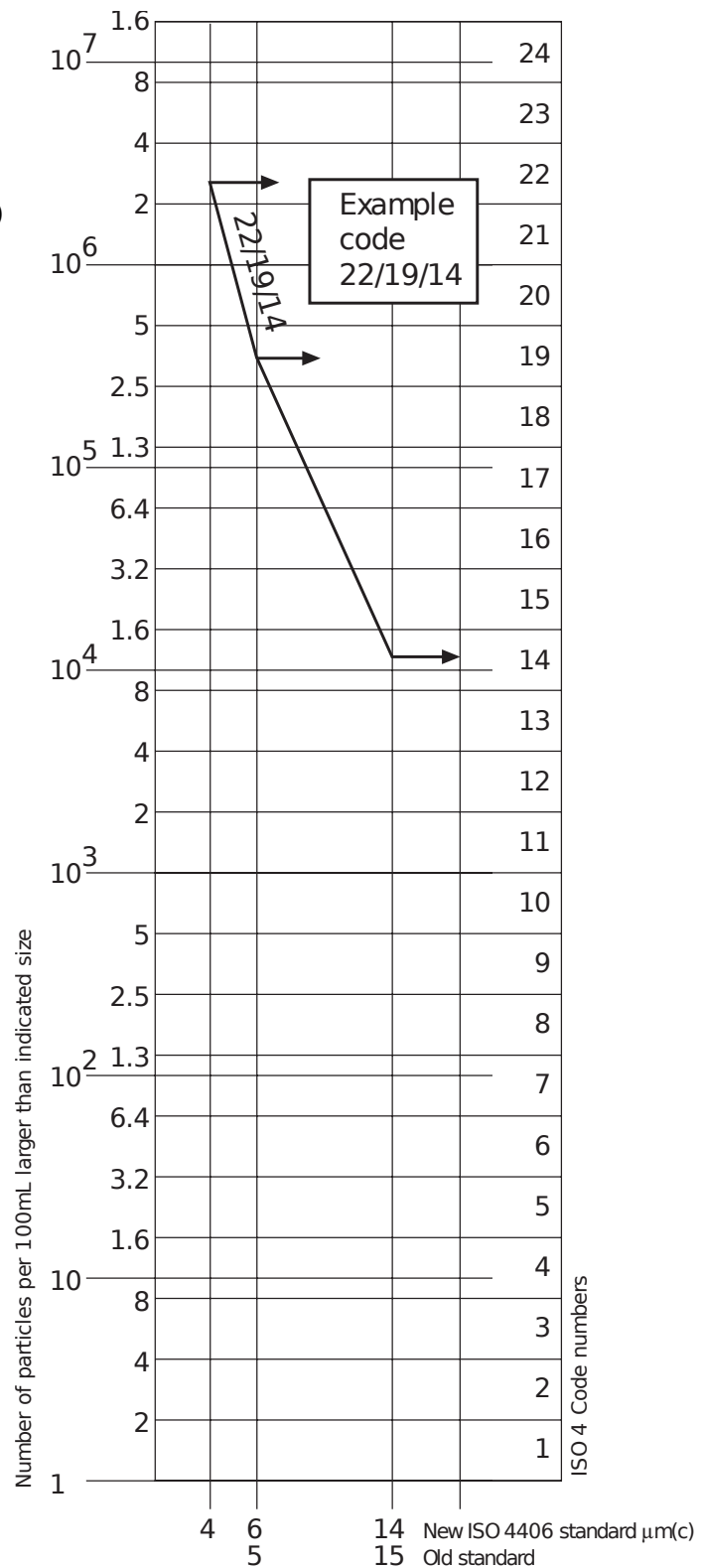
The *second* number represents the number of particles larger than 6  $\mu\text{m(c)}$ .

The *third* represents the number of particles that are larger than 14  $\mu\text{m(c)}$

Number of Particles per mL		Scale No.
More than	Up to and including	
2.5M	-	> 28
1.3M	2.5M	28
640k	1.3M	27
320k	640k	26
160k	320k	25
80k	160k	24
40k	80k	23
20k	40k	22
10k	20k	21
5000	10k	20
2500	5000	19
1300	2500	18
640	1300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5.0	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0.0	0.01	0

## APPENDIX B

Microscope counting examines the particles differently to APCs and the code is given with two scale numbers only. These are at 5  $\mu\text{m}$  and 15  $\mu\text{m}$  equivalent to the 6  $\mu\text{m(c)}$  and 14  $\mu\text{m(c)}$  of the APCs.



## NAS1638 Cleanliness Code System

The NAS system was originally developed in 1964 to define contamination classes for the contamination contained within aircraft components. The application of this standard was extended to industrial hydraulic systems simply because nothing else existed at the time. The coding system defines the maximum numbers permitted of 100ml volume at various size intervals (differential counts) rather than using cumulative counts as in ISO 4406:1999. Although there is no guidance given in the standard on how to quote the levels, most industrial users quote a single code which is the highest recorded in all sizes and this convention is used on the PML<sup>2</sup> software.

	00	0	1	2	3	4	5	6	7	8	9	10	11	12
<b>5-15</b>	125	250	500	1000	2000	4000	8000	16000	32000	64000	128000	256000	512000	1024000
<b>15-25</b>	22	44	89	178	356	712	1425	2850	5700	11400	22800	45600	91200	182400
<b>25-50</b>	4	8	16	32	63	126	253	506	1012	2025	4050	8100	16200	32400
<b>50-100</b>	1	2	3	6	11	22	45	90	180	360	720	1440	2880	5760
<b>Over 100</b>	0	0	1	1	2	4	8	16	32	64	128	256	512	1024

**Figure I** CONTAMINATION LEVEL CLASSES  
according to NAS1638 (January 1964).

The contamination classes are defined by a number (from 00 to 12) which indicates the maximum number of particles per 100 ml, counted on a differential basis, in a given size bracket.

## SAE AS4059 REV.E Cleanliness Classification For Hydraulic Fluids<sup>VII</sup>

This SAE Aerospace Standard (AS) defines cleanliness levels for particulate contamination of hydraulic fluids and includes methods of reporting data relating to the contamination levels. Tables 1 and 2 below provide the Maximum Contamination Limits (Particles/100ml) of differential and cumulative particle counts respectively for counts obtained by an automatic particle counter, e.g. PML<sup>2</sup>.

Size range $\mu\text{m(c)}$ :	6 - 14	14 - 21	21 - 38	38 - 70	>70
Class					
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1,000	178	32	6	1
3	2,000	356	63	11	2
4	4,000	712	126	22	4
5	8,000	1,425	253	45	8
6	16,000	2,850	506	90	16
7	32,000	5,700	1,012	180	32
8	64,000	11,400	2,025	360	64
9	128,000	22,800	4,050	720	128
10	256,000	45,600	8,100	1,440	256
11	512,000	91,200	16,200	2,880	512
12	1,024,000	182,400	32,400	5,760	1,024

**Table I AS4059E Table 1** - Cleanliness Classes for Differential Particle Counts

<sup>VII</sup> The information reproduced on this and the previous page is a brief extract from SAE AS4059 Rev.E, revised in May 2005. For further details and explanations refer to the full Standard.

Size $\mu\text{m(c)}$	>4	>6	>14	>21	>38	>70
Size Code	A	B	C	D	E	F
Classes						
000	195	76	14	3	1	0
00	390	152	27	5	1	0
0	780	304	54	10	2	0
1	1,560	609	109	20	4	1
2	3,120	1,217	217	39	7	1
3	6,250	2,432	432	76	13	2
4	12,500	4,864	864	152	26	4
5	25,000	9,731	1,731	306	53	8
6	50,000	19,462	3,462	612	106	16
7	100,000	38,924	6,924	1,224	212	32
8	200,000	77,849	13,849	2,449	424	64
9	400,000	155,698	27,698	4,898	848	128
10	800,000	311,396	55,396	9,796	1,696	256
11	1,600,000	622,792	110,792	19,592	3,392	512
12	3,200,000	1,245,584	221,584	39,184	6,784	1,024

**Table II AS4059E Table 2** - Cleanliness Classes for Cumulative Particle Counts

## Recommendations

<i>Unit</i>	<i>Type</i>	<i>ISO 4406:1999 Code</i>
<b>PUMP</b>	Piston (slow speed, in-line)	22/20/16
	Piston (high speed, variable)	17/15/13
	Gear	19/17/15
	Vane	18/16/14
<b>MOTOR</b>	Axial piston	18/16/13
	Radial piston	19/17/13
	Gear	20/18/15
	Vane	19/17/14
<b>VALVE</b>	Directional (solenoid)	20/18/15
	Pressure control (modulating)	19/17/14
	Flow control	19/17/14
	Check valve	20/18/15
	Cartridge valve	20/18/15
	Proportional	18/16/13
	Servo-valve	16/14/11
<b>ACTUATOR</b>		20/18/15

**Table I** Typical Manufacturers Recommendations for Component Cleanliness (ISO 4406:1999)<sup>VIII</sup>

Most component manufacturers know the proportionate effect that increased dirt level has on the performance of their components and issue maximum permissible contamination levels. They state that operating components on fluids which are cleaner than those stated will increase life. However, the diversity of hydraulic systems in terms of pressure, duty cycles, environments, lubrication required, contaminant types, etc, makes it almost impossible to predict the components service life over and above that which can be reasonably expected. Furthermore, without the benefits of significant research material and the existence of standard contaminant sensitivity tests, manufacturers who publish recommendations that are cleaner than competitors may be viewed as having a more sensitive product.

Hence there may be a possible source of conflicting information when comparing cleanliness levels recommended from different sources.

<sup>VIII</sup> It should be noted that the recommendations made in this table should be viewed as starting levels and may have to be modified in light of operational experiences or user requirements.

The table gives a selection of maximum contamination levels that are typically issued by component manufacturers. These relate to the use of the correct viscosity mineral fluid. An even cleaner level may be needed if the operation is severe, such as high frequency fluctuations in loading, high temperature or high failure risk.

## Hydraulic System Target Cleanliness Levels

Where a hydraulic system user has been able to check cleanliness levels over a considerable period, the acceptability, or otherwise, of those levels can be verified. Thus if no failures have occurred, the average level measured may well be one which could be made a bench mark. However, such a level may have to be modified if the conditions change, or if specific contaminant-sensitive components are added to the system. The demand for greater reliability may also necessitate an improved cleanliness level.

The level of acceptability depends on three features:

- the contamination sensitivity of the components
- the operational conditions of the system
- the required reliability and life expectancy

Contamination Codes ISO 4406:1999			Corresponding Codes NAS 1638	Recommended Filtration Degree	Typical Applications
4 µm(c)	6 µm(c)	14 µm(c)		Bx200	
14	12	9	3	3	High precision and laboratory servo-systems
17	15	11	6	3-6	Robotic and servo-systems
18	16	13	7	10-12	Very sensitive - high reliability systems
20	18	14	9	12-15	Sensitive - reliable systems
21	19	16	10	15-25	General equipment of limited reliability
23	21	18	12	25-40	Low - pressure equipment not in continuous service



The table above is a guide to the recommended filtration level for various hydraulic components, together with typical target system cleanliness levels.

## **New ISO Medium Test Dust and its effect on ISO Contamination Control Standards**

When General Motors gave advance warning to the International Standards Organization (ISO) that it was intending to stop the production of AC Fine Test Dust (ACFTD), work commenced immediately on finding an improved replacement dust. ACFTD was used extensively within the fluid power and automotive industries for calibrating Automatic Particle Counters (APCs) and for the testing of components.

APCs are used for testing oil filters, and also for contaminant sensitivity testing of hydraulic components. For 25 years, APCs have been the main stay in the measurement of solid particles in hydraulic fluids. The growth in demand for measuring fluid cleanliness in a variety of industrial processes, including fluid power, has resulted in APCs moving from the laboratory environment out into the factory. In fact, they are now a critical part of many production processes. It is therefore essential that the data they provide is both accurate and consistent.

### **Calibration**

ACFTD has been used as an artificial contaminant since the 1960s and its original particle size distribution was determined using an optical microscope. This particle size distribution subsequently formed the basis of ISO 4402, the method for calibrating APCs. Due to the limitations of that method of measurement, the particle size distribution was questioned below about 5 $\mu$ m. It was also not traceable to any national standard of measurement - a critical requirement for today's quality management systems.

There was also an absence of formal controls over the distribution of the test dust, and batch-to-batch variability was much greater than is acceptable nowadays.

ISO therefore defined the requirements for the replacement for ACFTD and asked the National Institute of Standards and Technology (NIST) in the USA to produce a standard, traceable reference material. The new dust's particle size distribution has been accurately determined with the aid of modern scanning electron microscope and image analysis techniques.

## New Test Dust Benefits

The new ISO Medium Test Dust (ISO MTD) consists of similar materials to the old ACFTD, but to minimize particle counting errors, it is of a slightly coarser grade because ACFTD included too many particles smaller than 5µm which gave problems during testing.

ISO MTD is produced to a standard distribution and stringent quality control procedures, thereby ensuring excellent batch-to-batch repeatability. These procedures, combined with a revised ISO APC calibration method give:

- A traceable and controlled reference test dust with greatly reduced variation in particle size distribution. This gives the trace-ability required by ISO 9000, QS9000 and similar quality management systems.
- A procedure for determining the performance of APCs so that minimum acceptable levels can be set by the user.
- Improved calibration techniques and procedures.
- More accurate calibration.
- Improved levels of particle count reproducibility with different equipment.
- More accurate and consistent filter test results.

## Effect on Industry

The introduction of ISO MTD has necessitated changes to certain ISO standards.

The standards affected include:

- |               |   |
|---------------|---|
| ISO 4402:1991 | Hydraulic fluid power<br>Calibration of liquid automatic particle counters.                                     |
| ISO 4406:1987 | Hydraulic fluid power<br>Code for defining the level of contamination by solid particles.                       |
| ISO 4572:1981 | Hydraulic fluid power – Filters<br>Multi-pass method for evaluating filtration performance of a filter element. |

## APPENDIX G

In order that users are not confused by the changes to these standards, particularly by reference to them in technical literature, ISO is updating 4402 to ISO 11171, and 4572 to ISO 16889.

Two standards which concern our industry are the ISO 4406 coding system and the new ISO 16889 Multi-pass test. As APCs will henceforth count particles more accurately, there will now be a change in the way sizes are labelled.

In the new ISO 4406:1999, new calibration sizes are used to give the same cleanliness codes as the 'old' calibration sizes of 5 and 15  $\mu\text{m}$ . In this way, there will be no necessity to change any system cleanliness specifications. It is proposed that the cleanliness codes (for APCs) will be formed from three<sup>IX</sup> particle counts at 4, 6 and 14  $\mu\text{m}$ , with 6 and 14  $\mu\text{m}$  corresponding very closely to the previous 5 and 15  $\mu\text{m}$  measurements. This will ensure consistency in data reporting.

As the counts derived by microscope counting methods are not affected, the particle sizes used for microscopy will remain unchanged (i.e. at 5 and 15  $\mu\text{m}$ ).

To clarify matters still further, ISO standards written around the new test dust will utilize a new identifier, '(c)'. Hence  $\mu\text{m}$  sizes according to the new ISO 11171 will be expressed as ' $\mu\text{m}(c)$ ' and Beta ratios according to ISO 16889 will be expressed as 'Bx(c)', e.g. 'B5(c)'.

However, it must be stressed that the only real effect users will experience will be the improved accuracy in particle counts - there will be no change in the performance of filters, nor in the ISO cleanliness levels that they will achieve.

The following charts shows the correlation between the old ACFTD and the new ISO MTD.

The PML<sup>2</sup> is calibrated with ISO Medium Test Dust (to ISO 11171). The correlation between particle sizes and the ACFTD (old standard) to the ISO MTD (new standard) is as follows :

ACFTD	<1	5	15	25	30	50	75	100
ISO MTD	4	6	14	21	25	38	50 <sup>X</sup>	70 <sup>XI</sup>

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<sup>IX</sup> The option of quoting just two counts of 6 $\mu\text{m}$  and 14 $\mu\text{m}$  for APCs remains.

<sup>X</sup> Not verified by NIST

<sup>XI</sup> acftd

## Correlation

The table shows the correlation between Particle Sizes Obtained using ACFTD (ISO 4402:1991) and NIST (ISO 11171) Calibration Methods

*This table is only a guideline. The exact relationship between ACFTD sizes and the NIST sizes may vary from instrument to instrument depending on the characteristics of the particle counter and original ACFTD calibration.*

Particle Size ACFTD (ISO 4402:1991) $\mu\text{m}$	Particle Size Obtained Using ISO/NIST MTD (ISO 11171) $\mu\text{m(c)}$
1	4.2
2	4.6
3	5.1
4	5.8
5	6.4
6	7.1
7	7.7
8	8.4
9	9.1
10	9.8
11	10.6
12	11.3
13	12.1
14	12.9
15	13.6
16	14.4
17	15.2
18	15.9
19	16.7
20	17.5
21	18.2
22	19.0
23	19.7
24	20.5
25	21.2
26	22.0
27	22.7
28	23.5
29	24.2
30	24.9
31	25.7
32	26.4
33	27.1
34	27.9
35	28.5
36	29.2
37	29.9
38	30.5
39	31.1
40	31.7

## Other Standards

Although the ISO 4406:1999 standard is being used extensively within the hydraulics industry other standards are occasionally required and a comparison may be requested. The following table gives a very general comparison but often no direct comparison is

## APPENDIX G

possible due to the different classes and sizes involved.

ISO 4406:1999	DEF.STD 05/42 [7] <sup>XII</sup>		NAS 1638[5]	SAE 749[8]
	Table A	Table B	ISO 11218[6]	
13/11/08			2	
14/12/09			3	0
15/13/10			4	1
16/14/09		400F		
16/14/11			5	2
17/15/09	400			
17/15/10		800F		
17/15/12			6	3
18/16/10	800			
18/16/11		1,300F		
18/16/13			7	4
19/17/11	1,300	2000F		
19/17/14			8	5
20/18/12	2,000			
20/18/13		4,400F		
20/18/15			9	6
21/19/13	4,400	6,300F		
21/19/16			10	
22/20/13	6,300			
22/20/17			11	
23/12/14	15,000			
23/21/18			12	
24/22/15	21,000			
25/23/17	100,000			

**Table I**

<sup>XII</sup> All section headings indicated with [] are reproduced by kind permission of British Fluid Power Association from BFPA/P5 1999 issue 3 Appendix 44

## Clean working practises

The majority of hydraulic systems require cleanliness which controls below around a 40 micron threshold (beyond the limit of human eyesight). When analysing particles down to levels of 4µm, 6µm & 14µm you are talking about objects of a cellular/bacterial size. This creates various challenges, and is starting to drive better and cleaner working practices in industry. Our products are at the forefront of this challenge, and will help you to manage the quality and productivity of your systems.

### Do's

- Do use filter breathers on tank tops.
- Do use tank designs, which are self draining (sloped or conical).
- Do use tanks which can be sealed off from the surrounding environment.
- Do exercise care and use funnels when filling tanks with fluid.
- Do utilize stainless steel and methods such as electro-polishing in the design of system components upstream of your first filter set.
- Do perform off-line analysis in a controlled environment such as a laboratory which should contain fewer airborne contaminants than where the sample was taken from.
- Do use suitable, glass bottles (ideally certified clean) to take samples, along with a hand pump to reduce contamination ingress.
- Do filter your system thoroughly before using it in your production process.
- Do perform a statistically large enough sample of particle analysis results ( 25) to arrive at a base cleanliness level for your system.
- Do make sure that filters are correctly sized for your applications and cleanliness you are trying to achieve.

### Don'ts

## APPENDIX H

- Don't eat, drink or smoke around critical systems/processes.
- Don't leave tools, objects, clothing or other materials etc. on surfaces or tanks of critical systems.
- Don't use open tanks on critical systems.
- Don't take samples or perform on-line analysis from the top of a reservoir/tank.
- Don't design/use tanks which contain crevices (internal corners etc).
- Don't assume that if a sample looks clean, that it is. You won't be able to see the contaminants.
- Don't perform off-line analysis in an "un-controlled" environment. E.g. workshop.
- Don't rely on a single test for a capable representation of your system.
- Don't start using your system/process until it has gone through a commissioning period whereby contamination levels are relatively stable.
- Don't mix fluids into the same system. They can emulsify and eliminate any chance of a reliable particle count.
- Don't use unsuitable containers to take a fluid sample.



## Specification

*As a policy of continual improvement, MP Filtri UK reserve the right to alter the specification without prior notice.*

<b><i>Technology</i></b>	Automatic Optical Particle Analyser
<b><i>Laser Package</i></b>	Twin Laser and Twin Optical Diode Detectors
<b><i>Sensitivity</i></b>	>4,6,14,21,25,38,50,70 µm(c) sizes to revised ISO 4406: 1999 Standard
<b><i>Accuracy / repeatability</i></b>	Better than 3% typical
<b><i>Calibration</i></b>	Each unit is individually calibrated with ISO Medium Test Dust (MTD) based on ISO11171:1999 on equipment certified by I.F.T.S.
<b><i>Analysis Range</i></b>	ISO 8 to ISO 24 to ISO 4406: 1999 NAS 1638: 2 to 12 AS4059E Table 1: 2 to 12 AS4059E Table 2: Size Codes A: 000 to 12, B: 00 to 12, C: 00 to 12, D: 2 to 12, E: 4 to 12, F: 7 to 12
<b><i>PML<sup>2</sup> Sample volume</i></b>	15 ml. (normal) 30 ml. (dynamic) 24 ml. (bottle sampler) 15 ml. (continuous) 8ml. (short)
<b><i>Operation</i></b>	Max. system working pressure: 400 bar. Min. working pressure: 2 bar
<b><i>Viscosity range</i></b>	to 400 centistokes
<b><i>Operating temperature</i></b>	+5 to +80°C
<b><i>Electrical Requirement</i></b>	24V DC 1 amp max. current
<b><i>Moisture &amp; Temp Meas.</i></b>	Included on PML <sup>2</sup> -W model
<b><i>Fluid compatibility</i></b>	Mineral oil & petroleum based fluids (consult MP Filtri UK for other fluids)

## APPENDIX I

<b><i>Typical test time</i></b>	Result in <2.5 mins. (normal test)
<b><i>Data storage</i></b>	600 tests
<b><i>Computer interface</i></b>	RS 232 communication port
<b><i>Hose connections</i></b>	Minimess fittings Microbore hose 1.5 metres long Waste fluid hose
<b><i>Dimensions</i></b>	Height 120mm Length 277mm Width 280mm Weight 5.9 kilos
<b><i>IP Rating</i></b>	IP66
<b><i>Operation</i></b>	Model A (Design Reference 30): Minimum oil inlet pressure: 2 bar Maximum oil inlet pressure: 400 bar Drain Reservoir/System: atmospheric, zero back pressure. Model B (Design Reference 31): Minimum oil inlet pressure: 10 bar Maximum oil inlet pressure: 400 bar Drain Reservoir/System: Back pressure not exceeding 1 bar.

### **Analyser Upper Contamination Limmit**

The analyser upper operating limit is set at 24/22/20. Tests that result in particle counts exceeding any scale number in the three part ISO upper limit has the scale number replaced by asterisk on the remote Display (optional equipment), example \*/\*/\*. Similarly for NAS1638/AS4059E-1 and AS4059E-2 the Display will show \*\* and \* respectively.

Within LPA-View, exceeding the upper contamination level is denoted by the use of code 25 in the case of ISO, and Class 15 for NAS1638/AS4059E-1 and AS4059E-2.

## **Spare Product / Part Numbers**

For spares and part numbers please see the website:

[www.mpfiltri.co.uk](http://www.mpfiltri.co.uk)

## Fault Finding

### FAULT

### CHECK

*Unexpected results obtained from sample*

Check that the minimess hose has been fully connected at both the system and the PML<sup>2</sup> ends.

Confirm that there is a free flow of fluid to the PML<sup>2</sup>, by operating the flush valve and observing fluid passing to waste.

High water/ aeration levels.

*Test stops after sampling has commenced*

If low pressure status is shown on the Remote Device dialogue, check that the fluid supply to the PML<sup>2</sup> is connected and pressurised.

*Remote Device dialogue not responding to buttons being pressed*

Check that correct COM port has been selected in the Remote Device dialogue.

Disconnect power supply to PML<sup>2</sup> and then reconnect it.

If excessive system contamination is suspected, flush out the Analyser using a Bottle Sampling Unit in conjunction with a suitable solvent. Refer to the website for more information on flushing fluids. [www.mpfiltri.co.uk](http://www.mpfiltri.co.uk)

***DO NOT USE ACETONE***

### Low Pressure

The PML<sup>2</sup> must always be connected to an inlet oil supply when carrying out a test, as operating the unit 'dry' could cause internal damage to the pump etc. To prevent this happening a switch is incorporated inside the PML<sup>2</sup> which detects low pressure and stops the test. If this occurs the status on the Remote Device dialogue will be shown as 'Low Pressure', and 'L' will also be displayed on the Remote Display is being used with the unit.

However to allow the user to become familiar with the software a Simulate Test facility has been provided - refer to page 15 for details.

If the unit is being operated in the Continuous Test mode when low pressure is detected the following will occur automatically:

- The sampling cycle will stop.
- The flush valve will open and the internal PML<sup>2</sup> syringe pump will empty.
- Flush valve closes.
- PML<sup>2</sup> waits for oil inlet pressure to be restored, at which point the PML<sup>2</sup> will automatically resume testing.

Note! If the PML<sup>2</sup> had been set to carry-out a relative humidity test when the low pressure event occurred, the first RH result after pressure has been restored will be invalid and should be discounted.



***Produced by MP Filtri UK***

## **Revision 8.1**

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MP FILTRI UK Limited,  
Bourton Industrial Park,  
Bourton-on-the-Water,  
GL54 2HQ, U.K.

Tel: +44.1451-822522  
Fax: +44.1451-822282  
Email: [sales@mpfiltri.co.uk](mailto:sales@mpfiltri.co.uk)  
Website: [www.mpfiltri.co.uk](http://www.mpfiltri.co.uk)

**[www.mpfiltri.co.uk](http://www.mpfiltri.co.uk)**

#### **ITALY - HEADQUARTERS**

MP FILTRI S.p.A.  
Tel: +39.02/95703.1  
Fax: +39.02/95741497-95740188  
Email: [sales@mpfiltri.com](mailto:sales@mpfiltri.com)  
Website: [www.mpfiltri.com](http://www.mpfiltri.com)

#### **CANADA**

MP FILTRI CANADA INC.  
Tel: +1.905-303-1369  
Fax: +1.905-303-7256  
Email: [mail@mpfiltricanada.com](mailto:mail@mpfiltricanada.com)  
Website: [www.mpfiltricanada.com](http://www.mpfiltricanada.com)

#### **CHINA**

MP FILTRI (Shanghai) Co Ltd  
Tel: +86.21-58919916  
Fax: + 86.21-58919667  
Email: [sales@mpfiltrishanghai.com](mailto:sales@mpfiltrishanghai.com)  
Website: [www.mpfiltrichina.com](http://www.mpfiltrichina.com)

#### **GERMANY**

MP FILTRI D GmbH  
Tel: +49.6894-95652-0  
Fax: + 49.6894-95652-20  
Email: [service@mpfiltri.de](mailto:service@mpfiltri.de)  
Website: [www.mpfiltri.de](http://www.mpfiltri.de)

#### **FRANCE**

MP FILTRI FRANCE  
Tel: +33.1.40-86-47-00  
Fax: +33.1-40-86-47-09  
Email: [contact@mpfiltrifrance.com](mailto:contact@mpfiltrifrance.com)  
Website: [www.mpfiltri.com](http://www.mpfiltri.com)

#### **INDIA**

MP FILTRI INDIA  
Tel: +91 9945599899  
Email: [s.mishra@mpfiltri.com](mailto:s.mishra@mpfiltri.com)  
Website: [www.mpfiltri.com](http://www.mpfiltri.com)

#### **RUSSIAN FEDERATION**

MP FILTRI RUSSIA INC  
Phone mobile: +7.095-502-5411  
Fax: +7.095-205-9410  
Email: [mpfiltrirussia@yahoo.com](mailto:mpfiltrirussia@yahoo.com)  
Website: [www.mpfiltri.ru](http://www.mpfiltri.ru)

#### **USA**

MP FILTRI USA Inc.  
Tel: +1.215-529-1300  
Fax: +1.215-529-1902  
Email: [sales@mpfiltriusa.com](mailto:sales@mpfiltriusa.com)  
Website: [www.mpfiltriusa.com](http://www.mpfiltriusa.com)

#### **UAE**

MP FILTRI UEA  
Tel: +91 9945599899  
Email: [s.mishra@mpfiltri.com](mailto:s.mishra@mpfiltri.com)  
Website: [www.mpfiltri.com](http://www.mpfiltri.com)